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(54) **Satellite antenna system.**

(57) The invention relates to a satellite antenna system particularly for land mobile voice communication, comprising a radiator unit (1') which is steerable to the satellite in the azimuth plane. According to the invention, the satellite antenna system includes a number of antenna elements (1; 1^1 – 1^{12}), of which the radiator unit (1') is formed, a control unit (4) and a switching unit (5); the antenna elements of the said radiator unit are adjacently arranged and evenly spaced in a circular configuration, and of these antenna elements, two adjacent elements belong simultaneously to one and the same active antenna unit (6), and the said two elements are chosen by means of the control unit and the switching unit to receive circularly polarized electromagnetic radiation from a desired direction, and to transmit the same to essentially the same direction.

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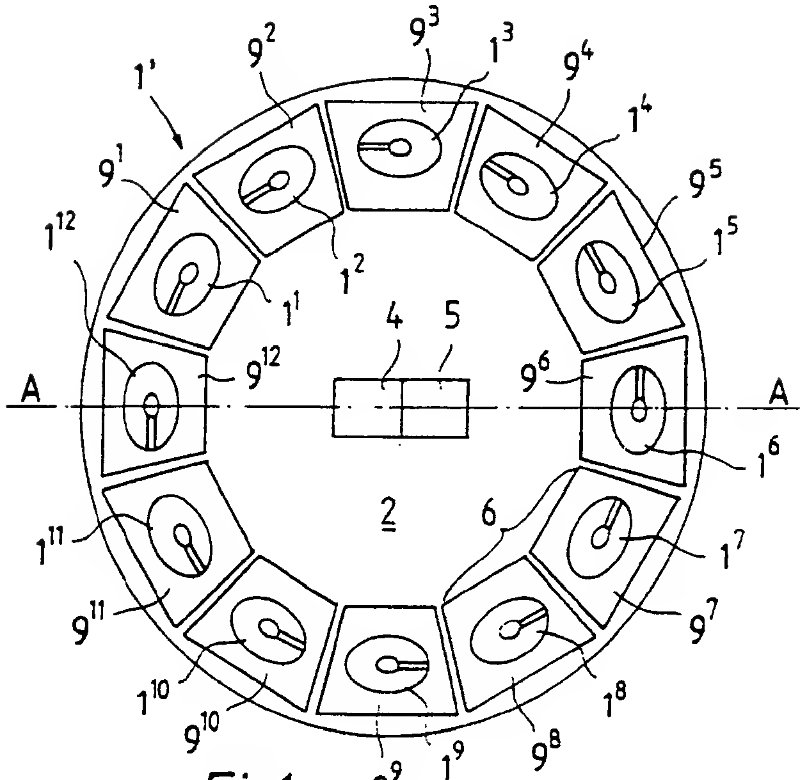

1'
9^2
9^3
1^3
9^4
1^4
9^1
9^5
1^{12}
1^5
1^2
1^1
4
5
9^{12}
9^6
A
A
1^6
2
6
1^{11}
1^7
9^{11}
9^7
1^{10}
1^8
9^{10}
9^8
1^9
9^9
Fig1

The invention relates to a satellite antenna system defined in the introductory section of patent claim 1, particularly for a land mobile terminal for voice communications.

New satellite systems are under development, especially for land mobile communications. Data transmission and localisation services, such as Inmarsat C, PRODAT, Euteltracks and Lockstar, have already been demonstrated and are gradually coming into operational use. Market surveys also show, that there is a demand for voice communications. Two systems, EMS (European Mobile System) and Inmarsat M, are under development for L-band land mobile voice communications. These systems complement particularly terrestrial mobile servcices by providing flexible closed networks having a European wide coverage area. One of the most promising applications is private networks for truck communications.

Omnidirectional antennas can be used with low rate data transmission. The gain with these antennas is of the order 3...5 dBi, which is generally sufficient. However, voice communications need a better signal to noise ratio than the one offered by omnidirectional antennas. This leads to an antenna gain requirement of the order 10...12 dBi. In the prior art there are known several antenna systems where the antenna element is steerable. Such antennas are, among others, certain slot and horn antennas, as well as dipole antennas. A drawback with these antenna units is the complexity of feed network applications, and their unsuitability for various tracking systems. Moreover, the mechanical properties of these antennas are often unsuitable particularly with respect to land mobile terminals.

The object of the invention is to provide a new antenna system, whereby the above mentioned drawbacks can be eliminated. Another object of the invention is to achieve an antenna system which is economical in production costs and suitable for mass production.

The antenna system of the invention is characterized by the features enlisted in the patent claim 1.

The satellite antenna system of the invention particularly for a mobile land terminal for voice communications comprises a radiator unit, which in the azimuth plane is steerable to the satellite. According to the invention, the satellite antenna system includes an radiator unit formed of a number of antenna elements and ground planes, a control unit and a switching unit, the said antenna elements of the radiator unit being arranged adjacently in a circular configuration; among these antenna elements, two adjacent elements belong simultaneously to the same active antenna unit, and the said elements are chosen by means of the control unit and the switching unit to receive circularly polarized electromagnetic radiation from a desired direction, and to transmit the same essentially to the same direction.

Advantageously the antenna elements are travelling-wave type air dielectric antenna elements, which are identical in structure. The antenna elements are arranged in a circular configuration, so that they cover the whole circumference of 360°. In the satellite antenna system, there can then be chosen, by means of the control unit and the switching unit, the two antenna elements that have their beams oriented to the desired direction.

In a preferred embodiment of the satellite antenna system, each antenna element is formed of thin plate made of some conductive material, advantageously metal, and each antenna element includes a planar or platelike, circular part, i.e. a curved part, which advantageously has a standard width and is arranged at a standard distance from the ground plane, and narrowing, advantageously triangular points, which are located at both ends of the curved part and are arranged at an angle with respect to the plane of the curved part and towards the ground plane; at the tips of the said points, there are located poles, the first of which is coupled to the feed/reception circuit, and the second to the load. The antenna elements together with their ground planes are arranged in similar position, i.e. at a similar elevation angle, adjacently in a circular configuration.

In another preferred embodiment of the satellite antenna system, the points of each antenna element are formed as blunt tips, advantageously evenly cut blunt tips, and in the vicinity of these blunt tips, there are located poles in an unsymmetrical fashion with respect to the shape of the tips. With this location of the poles, an excellent matching is achieved between the antenna element, its feed/reception circuit and the load.

In another preferred embodiment of the satellite antenna system, the ground plane of each antenna element is formed as a trough-like member, wherein the antenna element is installed. The mechanical structure of such a ground plane is stiff. Moreover, by using this type of ground plane, a better isolation between neighboring antenna elements is achieved. In addition, this type of ground plane has a stabilizing effect on the feed point impedance.

In another preferred embodiment of the satellite antenna system, the switching unit comprises two switch groups, whereby two adjacent antenna elements can be chosen at a desired spot in the circular configuration. The switch groups are advantageously formed of PIN diodes.

In another preferred embodiment of the satellite antenna system, the system includes a power

divider and phase shifter unit, comprising a 180° hybrid and two phase shifters, and the said power divider and phase shifter unit is connected to the switching unit.

In another preferred embodiment of the satellite antenna system, the phase shifter is of a loaded line type. It comprises two parallel transmission lines connected at one end to the input and output ports, and transmission lines between them and the input and output ports, as well as switching elements, installed at the ends of matching lines connected to the input and output ports, for realizing the phase shift. By means of the switching unit and the said phase shifters, three beams of deviating orientation can be realized for the the chosen two antenna elements, depending on the states of the phase shifter switches. Thus the beam of an active antenna unit composed of two antenna elements can advantageously be adjusted at for instance ±7° with respect to the average normal direction of the antenna elements, and the tracking of the satellite can be carried out in a flexible and reliable fashion. Moreover, with a relatively small number of antenna elements in the circular configuration, there can be produced at least a twofold number of beams, which cover the azimuth plane in an essentially gapless fashion.

In another preferred embodiment of the satellite antenna system, the antenna elements are provided with support members, whereby the antenna elements are arranged on a base element at a suitable elevation angle with respect to the azimuth plane. The elevation angle depends on the orbit location of the data communication satellite under tracking, and on the geographical location of the land terminal where the antenna system is being used.

In another preferred embodiment of the satellite antenna system, the support members are adjustable in order to adjust the elevation angle. By means of the support members, the elevation angles of all antenna elements are set to the same position in the azimuth plane, so that the elevation angles of the beams of the antenna elements are correct with respect to the location of the satellite. The elevation angle varies between 10 – 50°, and is advantageously adjustable for instance with 10° intervals. The width of the beam also covers the said 10° range without any remarkable loss of gain in the peripheral area of the beam.

In another preferred embodiment of the satellite antenna system, the system is provided with a radome.

In another preferred embodiment of the satellite antenna system, it comprises a steering unit for realizing the acquisition and tracking of the satellite. To the said steering unit there is connected a detecting and measuring unit in order to measure the signal level in the employed radio frequency band. The steering unit is connected to the control unit and the switching unit in order to choose the two co-operating antenna elements from among all elements, through which antenna elements the best signal level in the communication with the satellite is achieved. Most advantageously, the steering unit is realized with a microprocessor-based data processor, provided with a number of connector and peripheral devices. The various functions are suitably programmed in the steering unit.

An advantage of the invention is that the satellite antenna system is fairly simple and fits in a small space. The system is economical in production costs, and thus suitable for mass production.

Another advantage of the invention is that the radiator unit formed by the antenna elements, and the connected simple feed/reception system most advantageously produces 24 identical beams in the horizontal plane. By means of these beams, the whole angular range of the horizontal plane can be covered. The acquisition and tracking of the satellite signal are carried out completely electrically, without any moving parts.

Another advantage of the invention is that a high gain is achieved by using the active antenna unit comprising two antenna elements simultaneously.

Another advantage of the invention is that the feed network of the antenna system is relatively simple and offers an efficient and straightforward way to switch and phase-shift the desired beams among the chosen antenna elements.

Another advantage of the invention is that in relation to the number of antenna elements, a twofold number of beams is created. Among the antenna elements located in a circular configuration, there always are two active elements which produce two beams with predetermined phasing.

Another advantage of the invention is that the adjusting of the elevation angle is simple and can be carried out either mechanically or by using a suitable actuator.

Another advantage of the invention is that by means of the radiator unit, there is created a radiation pattern with a wide coverage area. The satellite antenna system is suitable for small elevation angles, starting from about 10°, which are particularly important in northern latitudes, with respect to the use of the antenna system.

As for the further advantages of the invention, the following can be maintained: the satellite acquisition routines function rapidly after switching the system on. The system also takes into account a fairly large steering error of the radiator unit, with respect to the band width and gain loss of the

antenna element. Moreover, an advantage of the system is that the signal to noise ratio is small. Further, the antenna system functions reliably irrespective of changes in short and long term signal levels. Yet another advantage of the antenna system is that it is rapidly recovered from disturbance situations. In addition, the antenna system causes a minimal amount of distortion to communication channels.

The invention is explained in more detail below, with reference to the appended drawings where

figure 1 is a top-view illustration of a satellite antenna system of the invention;
figure 2 gives a cross-section A - A of the satellite antenna system of figure 1;
figure 3a illustrates the antenna element seen from the top, and figure 3b the same antenna element seen from the side;
figure 4 is a block diagram of the main parts of the satellite antenna system of the invention;
figure 5 is a schematical illustration of the hybrid;
figure 6 is a schematical illustration of the phase shifter;
figure 7 is a layout of the power divider and phase shifter units;
figure 8 illustrates the beams; figure 8a illustrates the beams of the active pair of antenna elements, and
figure 8b illustrates the realizable beams of a radiator unit with 12 antenna elements; and
figure 9 is a block diagram of the steering unit, together with connected units and devices.

Figures 1 and 2 are schematical illustrations of a satellite antenna system of the invention. The antenna system comprises a radiator unit 1', with a number of identical antenna elements 1; 1^1 - 1^{12} and their ground planes 9; 9^1 - 9^{12}, which are arranged on a disc-like base element 2. They are installed adjacently in a circular configuration, on the periphery of the base element 2. They are arranged at regular intervals from each other, so that they cover the whole circumference sector by sector. In this preferred embodiment, the radiator unit 1' is formed of twelve antenna elements 1^1 - 1^{12} and twelve ground planes 9^1 - 9^{12}.

The antenna system also includes support members 3, whereby the elements 1^1 - 1^{12} and their ground planes 9^1 - 9^{12} of the radiator unit 1' are arranged at a suitable elevation angle α with respect to the base element 2. The support members 3 are for instance support bars, which are adjustable in length, either stepwise or continuously, manually or by means of a suitable actuator, in order to adjust the elevation angle α.

The antenna system also includes the control unit 4 and the switching unit 5. Among the antenna elements 1^1 - 1^{12}, to one and the same active antenna unit, for instance 6, there belong simultaneously two antenna elements 1^7, 1^8, which are chosen by means of the control unit 4 and the switching unit 5 to receive circularly polarized electromagnetic radiation from a desired direction, and to transmit the same to essentially the same direction.

The satellite antenna system is provided with a radome 7 in order to protect the antenna elements 1^1 - 1^{12} and other equipment pertaining to the antenna system.

The antenna elements 1; 1^1 - 1^{12} are identical, discrete travelling-wave type air dielectric elements, as is illustrated in figures 3a and 3b. Each antenna element 1 is formed of a thin plate 8 made of some conductive material, advantageously metal such as copper or brass. The antenna element 1 includes a platelike part, i.e. curved part 8a, which has a standard width and is essentially circular in shape. This curved part 8a fills a 270° sector of the circle. The nominal electric length of the curved part 8a is near the employed wavelength. The curved part 8a is fitted at a standard distance h from the ground plane 9.

At both ends of the curved part 8a, there are provided narrowing points 8b, 8c, advantageously having the shape of an isosceles triangle. The points 8b, 8c are arranged, with respect to the plane of the curved part 8a, at an angle towards the ground plane 9. They are advantageously made of the same uniform plate material as the curved part 8a and bent thereof. In between the points 8b, 8c there is a slot 10. The tips of the points 8b, 8c are formed to be blunt, and are advantageously cut as straight blunt tips 8d, 8e, as is illustrated in figure 3a. In the vicinity of the straight-cut tips 8d, 8e, unsymmetrically with respect to the medium lines D-D, E-E of the points 8b, 8c, i.e. at the sides of the blunt tips, there are arranged the poles 11, 12. One pole serves as the feed pole, and the other as the load. By forming the points 8b, 8c as blunt points, particularly as straight-cut blunt tips 8d, 8e, and by placing the poles 11, 12 in an unsymmetrical fashion, there is achieved an optimal matching (roughly 50 ohm) in between the antenna elements 14, 15 and the feed/reception circuit. The antenna element is symmetrical with respect to the straight line F-F running in the middle of the slot 10 and parallelly thereto. Depending on the employed direction of circular polarization, both poles 11, 12 can serve either as feed or load poles.

Coupling pins lead from the poles 11, 12 through the ground plane 9, electrically insulated therefrom, to the other side of the ground plane, where they are connected to the switching unit 5 and to the matched loads 15 (cf. figure 4). At the

blunt tips of the points 8b, 8c, such as the straight-cut tips 8d, 8e, the antenna element 1 is attached, by means of coupling pins, to the ground plane 9 serving as the base, but in such a fashion that an electrical connection is not created, i.e. an insulating plate or film is left in the coupling. Moreover, the antenna element 1 is supported, most advantageously in the middle of the curved part 8a, by an electrically insulating support 10a against the ground plane 9.

The radiation power of the antenna element 1; $1^1 - 1^{12}$ can be adjusted by adjusting the width b of the curved part 8a of the plate 8, as well as its distance h from the ground plane 9. An optimal antenna gain is achieved, when roughly 90% of the power fed in the antenna element produces radiation and 10% is absorbed in the matched load.

The active antenna unit, for instance 6 in figure 1, is formed electrically by choosing two adjacent antenna elements, such as 1^7, 1^8 from among the antenna elements $1^1 - 1^{12}$. Thus remarkable advantages are gained as compared to only one chosen antenna element. It has been found out that an optimal gain value and optimal width of the beam depend on the shape and size of the ground plane 9; $9^1 - 9^{12}$. The direction of the main beam maximum is somewhat dependent on the used frequency, and deviates from the ground plane normal for about 5 - 15°. This angle deviation is also dependent on the shape of the ground plane. By means of two cooperating adjacent antenna elements $1^1 - 1^{12}$, which elements are evenly spaced and fed parallelly with a suitable phase difference, the angular dependence of the main beam on the frequency can be practically eliminated.

The ground plane 9 is a trapezoid plane, the edges 9a, 9b, 9c and 9d whereof are turned upwards, so that the ground plane forms a shallow trough (note: in figure 3a, the edges are turned to horizontal plane for illustrative purposes). The central width 1 of the ground plane 9 is of the same order as the total width of the plate 8 and the distance a between the antenna elements, and the length k of the ground plane in turn is of the order 1.5 - 2.0 x a. The depth s of the trough-like ground plane is of the order 0.1a. In a preferred embodiment the dimensions of the ground plane are: height k = 150 mm, width on the wide side 11 = 150 mm, width on the narrow side 12 = 90 mm, and depth h of the ground plane = 20 mm. The ground plane 9 is made of some suitable conductive material, such as aluminium.

Figure 4 is a block diagram of the satellite antenna system of the invention. The feed points 11; $11^1 - 11^{12}$ of the antenna elements 1; $1^1 - 1^{12}$ of the radiator unit 1' are connected to the two switch groups 13, 14 of the switching unit 5, and respectively the second points 12; $12^1 - 12^{12}$ are connected to the matched loads 15; $15^1 - 15^{12}$. The antenna elements $1^1 - 1^{12}$ are grouped so that adjacent elements 1^1, 1^2; 1^2, 1^3; 1^3, 1^4, ... are connected to different switch groups 13, 14. Thus the antenna elements $1^1 - 1^{12}$ are connected alternately to the first switch group 13 or to the second switch group 14. In this case each switch group 13, 14, has six outputs 13; $13^1 - 13^6$ and 14; $14^1 - 14^6$. By means of the control unit 4, the switch groups are controlled so that two adjacent elements 1^1, 1^2; 1^2, 1^3; ... can always be chosen to function simultaneously as an active antenna unit.

The inputs 16, 17 of the switch groups 13, 14 are connected to the power divider and phase shifter unit 18. The power divider and phase shifter unit 18 comprises two phase shifters, i.e. the first phase shifter 19 and the second phase shifter 20, and a 180° hybrid 21. The first input 21a of the hybrid 21 is the input of the power divider and phase shifter unit 18, and it is connected to the detecting and measuring unit 29, as well as to the receiver-transmitter unit (not illustrated in the drawing). The second of the inputs of the hybrid 21 is grounded through the load 22. The outputs 21c, 21d of the hybrid 21 are respectively connected to the input of the first phase shifter 19 and to the input of the second phase shifter 20.

The hybrid 21 is schematically illustrated in figure 5. The input and output ports are denoted with the same reference numbers as in figure 4. The input port 21a is a difference or D-port, and the input port 21b is a sum or S-port. When a signal is fed in through the D-port, from the output ports 21c, 21d there are received output signals, which are in a 180° phase difference. When again a signal is fed from the S-port to the hybrid, the signals received from the output ports are in phase.

The phase shifters 19, 20 are realized by means of transmission cables and switch members, as is seen in figure 6. The phase shifter 19, 20 includes two parallel transmission cables 23a, 23b and 24a, 24b connected at one end to both the input and output port P1, P2, and transmission cables 25a, 25b connected in between the ports. In addition, the phase shifter 19, 20 comprises switch members 28a and 28b installed at both ports P1, P2, at the ends of the matching cables 26a, 26b; 27a, 27b. The switch members 28a, 28b are realized by means of suitable diodes, and they can be switched to on and off positions. Both switch members 28a, 28b are simultaneously in the same state, so that the phase shifter 19, 20 is symmetrical in structure. The shifting properties of the phase shifter 19, 20 from the port P1 to the port P2 or vice versa are thus similar. Such a loaded line type phase shifter 19, 20 has small losses and a wide frequency band. Moreover, the phase shifter

has good matching properties.

A preferred embodiment of the power divider and phase shifter unit 18 is illustrated as a layout in figure 7. The hybrid 21 and the phase shifters 19, 20 are produced on the same substrate by using the microslip method.

In this embodiment, the phase shifters 19, 20 are optimized to create a 33° phase shift. This means a roughly 14° (± 7° from straight middle line) angle difference for the beams obtained from the active antenna unit. By changing the states of the phase shifters 19, 20, and particularly the states of their switch members 31, 32, the direction of the beam of the active antenna unit can be shifted in between the normal, i.e. middle direction, and extreme positions of the ground plane 9, as is explained below.

The phase shifters 19, 20 are utilized in steering the beam while performing the satellite tracking. By suitably manipulating the switches 28a, 28b of the phase shifter 19, 20, it is possible to move from the "right" beam to the "left" beam or to the middle beam "mid", which beams are illustrated in figure 8a. The switching from the "right" beam to the "left" beam of vice versa is realized so, that the states of both switch members 28a, 28b of the phase shifters 19, 20 are changed. Thus the phase shifters become mirror images as regards their properties. Correspondingly, if the state of only one switch member, either 28a or 28b, is changed, the beam is shifted from the middle beam "mid" either to the "right" or "left" beam. The width of the beams is somewhat affected by the elevation angle α, and also the employed reception and transmission band. The above explained power divider and phase shifter unit 18 is mainly designed for the frequency band 1,5 – 1,7 GHz.

An active antenna unit is formed of two adjacent antenna elements 1^1, 1^2; 1^2, 1^3, ... For the active antenna unit, there can be arranged two beams as was explained above, the said beams deviating up to even 15°. By means of the radiator unit 1, a twofold number of beams is produced on the circle as compared to the number of the antenna elements 1^1 – 1^{12}. Thus 24 beams can be produced with 12 antenna elements, the said beams being spaced essentially evenly in a circular configuration in the azimuth plane. This is illustrated in figure 8b.

Figure 9 illustrates, in the form of a block diagram, the steering unit 30 together with the connector and peripheral devices. The steering unit 30 comprises a data processing unit 31a and a connected memory unit 31b. To the data processing unit 31a, there is further connected, by a suitable bus 32, a number of peripheral devices through the intermediation of the connector units, for instance the elevation angle detector 33 by intermediation of its connector unit 34, the A/D converter 35 of the detecting and measuring unit 29, the phase shifter switching unit 36 and the control 37 of the support members. The control unit 4 of the switching unit 5 also is connected to the bus 32 of the steering unit 30. In addition to this, the steering unit 30 includes a connector unit 38 for feeding information, such as programming and other information for the steering device, and a connector unit 39 for connecting the steering unit to external systems. Moreover, the steering unit 30 advantageously comprises a compass connector unit 40 in order to connect a compass 41 to the system.

The connector unit 34 of the elevation angle detector is connected to the elevation angle detector 33 measuring the elevation angle α of the antenna elements 1, and the said detector 33 is arranged in between the base element 3 and the antenna elements 1; 1^1 – 1^{12} (cf. figure 2). The detecting and measuring unit 29 contains an intermediate frequency unit and a rf-detector, as well as a measuring unit for measuring the rf-level. This measuring signal is fed to the steering unit via the A/D converter 35. The switching unit 36 is connected to the switch members 28a, 28b of the phase shifters 19 and 20 of the power divider and phase shifter unit 18. In this case the support members 3 are provided with an actuator 42 (cf. figure 2), such as electric motor, in order to lengthen and shorten the support members 3. The control 37 of the support members is connected to the actuator 42 of the support members.

By means of the steering unit 30, the acquisition and tracking of the satellite is carried out as follows. When starting the satellite antenna system, the elevation angle α of the elements 1^1 – 1^{12} of the radiator unit 1 is checked. If the elevation angle a does not correspond the location of the land terminal with respect to the latitude and the satellite, it is adjusted for instance at 10° intervals between 10 – 50°. The form and width of the beam is such, that the 10° adjusting steps are sufficient for a good antenna gain and signal to noise ratio. The correcting of the elevation angle α is carried out by adjusting the length of the support members 3 to be suitable by means of the actuator 42 of the support members, so that the desired elevation angle α is achieved. The information of the elevation angle α is sent to the steering unit 30 through the elevation angle detector 33.

After setting the elevation angle α, the acquisition of the satellite is started. The radio frequency level, i.e. rf-level of the satellite is measured by means of the detecting and measuring unit 29, by activating a pair of antenna elements 1^1, 1^2; 1^2, 1^3; 1^3, 1^4; etc, one pair at a time, so that all of the antenna elements 1^1 – 1^{12} are checked. The

measured rf-level values, obtained from the said antenna units activated in succession, are recorded in the memory 31b. During this measurement, the beams of each pair of antenna elements are observed, both the right and the left beam, so that the azimuth plane will be scanned throughout by the beams illustrated in figure 8b.

When the first series of measurements is made, in the radiator unit 1' there is activated that pair of antenna elements which gave the maximum rf-level signal. Thereafter the system proceeds to tracking.

The tracking phase is based on the tracking of the rf-signal level by means of two beams, i.e. the left and the right beam, as was explaned above in connection with the devider and phase shifter unit. By following this procedure, it is attempted to keep the active antenna unit continuously electrically steered to the target satellite, in order to maintain the communication connection irrespective of the movements of the land terminal.

The steering unit can be provided with an electric compass 41 or other such detector, so that the turning of the vehicle can be observed, and the steering unit 30 can be effectively helped in maintaining the radiator unit steered to the satellite.

In the above specification, the invention is described with reference to one preferred embodiment only, but many modifications are possible within the scope of the inventional idea defined in the appended patent claims.

Claims

1. A satellite antenna system particularly for land mobile voice communications, provided with a radiator unit (1') that is steerable to the satellite in the azimuth plane, **characterized** in that the satellite antenna system comprises a radiator unit (1') formed of a number of antenna elements (1; 1^1 - 1^{12}) and their ground planes (9; 9^1 - 9^{12}), a control unit (4) and a switching unit (5); that the antenna elements (1^1 - 1^{12}) of the radiator unit (1'), together with their ground planes (9^1 - 9^{12}) are adjacently arranged in a circular configuration, so that among the said antenna elements (1^1 - 1^{12}), to one active antenna unit (6) there belong simultaneously two adjacent antenna elements (1^7, 1^8), and the said two elements are chosen, by means of the control unit (4) and the switching unit (5), to receive circularly polarized electromagnetic radiation from a desired direction and to further transmit the same to essentially the same direction.

2. The satellite antenna system of claim 1, **characterized** in that each antenna element (1; 1^1 - 1^{12}) is formed of a thin plate (8) made of some conductive material, advantageously metal, and that each antenna element (1; 1^1 - 1^{12}) comprises a platelike, circular part, i.e. curved part (8a), which advantageously has a standard width (b) and is arranged at a standard distance (h) from the ground plane (9, 9^1 - 9^{12}), and narrowing, advantageously triangular points (8b, 8c), which are located at both ends of the curved part (8a) and arranged at an angle with respect to the plane of the curved part (8a) and towards the ground plane (9); and that at the tips of these points (8b, 8c) there are located poles (11, 12), the first whereof is coupled to the feed/reception circuit and the second to the load (15).

3. The satellite antenna system of claim 2, **characterized** in that the points (8b, 8c) of each antenna element are formed as blunt tips, advantageously straight-cut blunt tips (8d, 8e), and that in the vicinity of these blunt tips, there are located poles (11, 12) in an unsymmetrical fashion with respect to the shape of the tips.

4. The satellite antenna system of claim 1, 2 or 3, **characterized** in that the ground plane (9; 9^1 - 9^{12}) of each antenna element (1; 1^1 - 1^{12}) is formed as a trough-like element, wherein the antenna element (1; 1^1 - 1^{12}) is installed.

5. The satellite antenna system of claim 1, 2, 3 or 4, **characterized** in that the switching unit (5) comprises two switch groups (13, 14), whereby two adjacent antenna elements (1^1, 1^2; 1^2, 1^3; 1^3, 1^4; ...) can be chosen from a desired spot on the circular configuration.

6. The satellite antenna system of claim 5, **characterized in** that the antenna system comprises a power divider and phase shifter unit (18), provided with two phase shifters (19, 20) and a 180° hybrid (21), which power divider and phase shifter unit (18) is coupled to the switching unit (5).

7. The satellite antenna system of claim 6, **characterized** in that each phase shifter (19, 20) comprises two parallel transmission cables (23a, 23b; 24a, 24b) connected at one end to the input and output ports (P1, P2); transmission cables (25a, 25b) provided in betweeen the input and output ports (P1, P2); and switch members (28a, 28b), installed at the ends of the matched cables (26, 26b; 27a, 27b) connected to the input and output ports (P1, P2), in order to realize the phase shift.

8. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna elements (1; 1^1 – 1^{12}) are provided with support members (3), whereby the antenna elements are arranged on a base element (2) at a suitable elevation angle (α) with respect to the azimuth plane (B – B), and that the said support members (3) are advantageously adjustable members for adjusting the elevation angle (α).

9. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna system is covered with a radome (7).

10. The satellite antenna system of any of the preceding claims, **characterized** in that the antenna system is provided with a steering unit (30) for realizing the acquisition and tracking of the satellite, the said steering unit comprising a detecting and measuring unit (29) for measuring the rf-signal level; and that the said steering unit is connected to a control unit (4) and switching unit (5) for choosing two cooperating antenna elements (e.g. 6) among the antenna elements (1; 1^1 – 1^{12}), which two chosen antenna elements give the best signal level in data communication with the satellite.

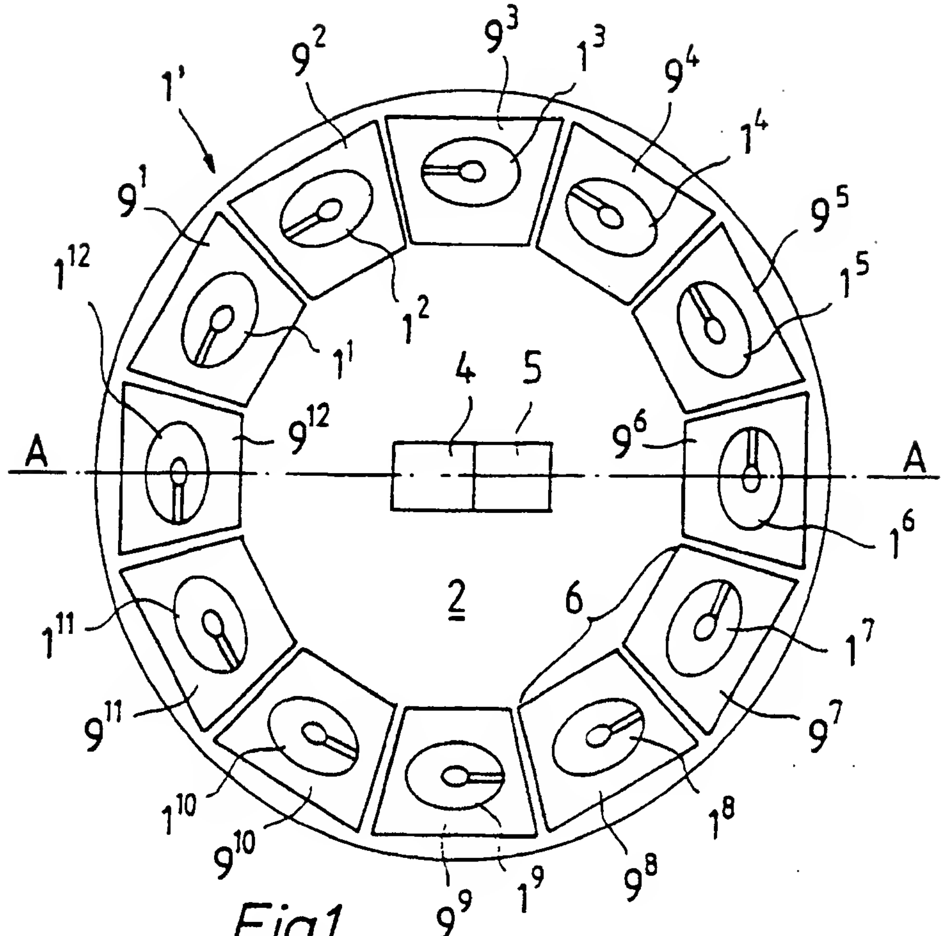


Fig1

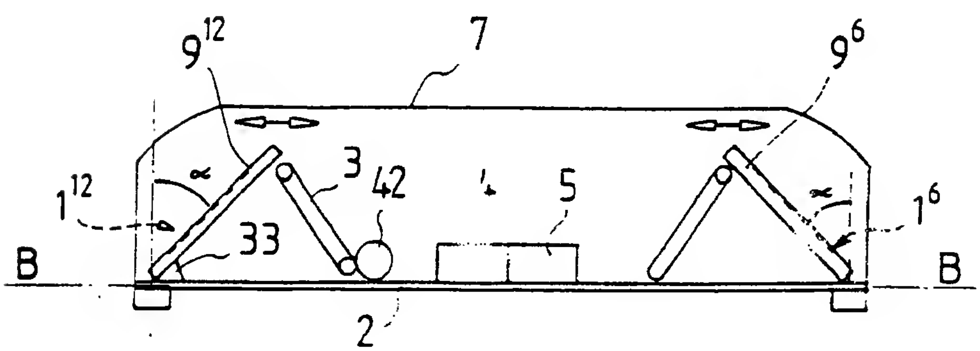


Fig.2

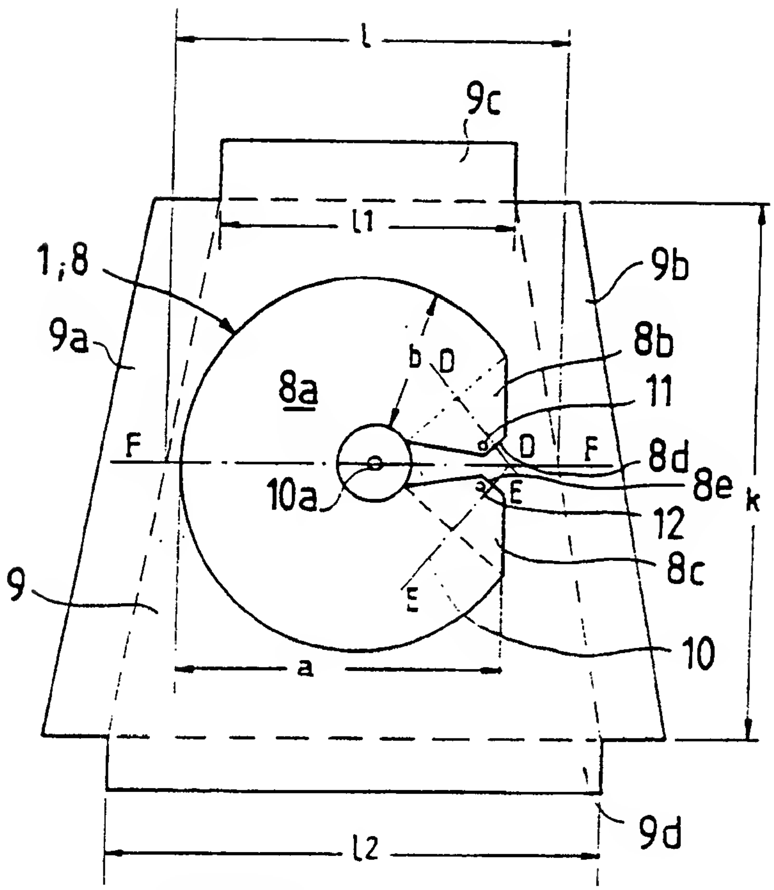

l
9c
l1
1;8
9b
9a
8b
b
D
8a
11
F
D
F
8d
8e
k
10a
E
12
8c
9
E
10
a
9d
l2

Fig.3a

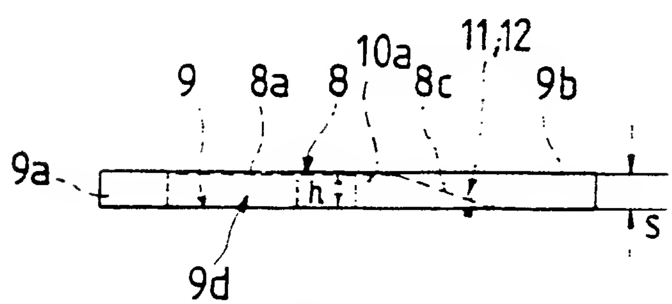

11;12
10a
9
8a
8
8c
9b
9a
h
s
9d

Fig.3b

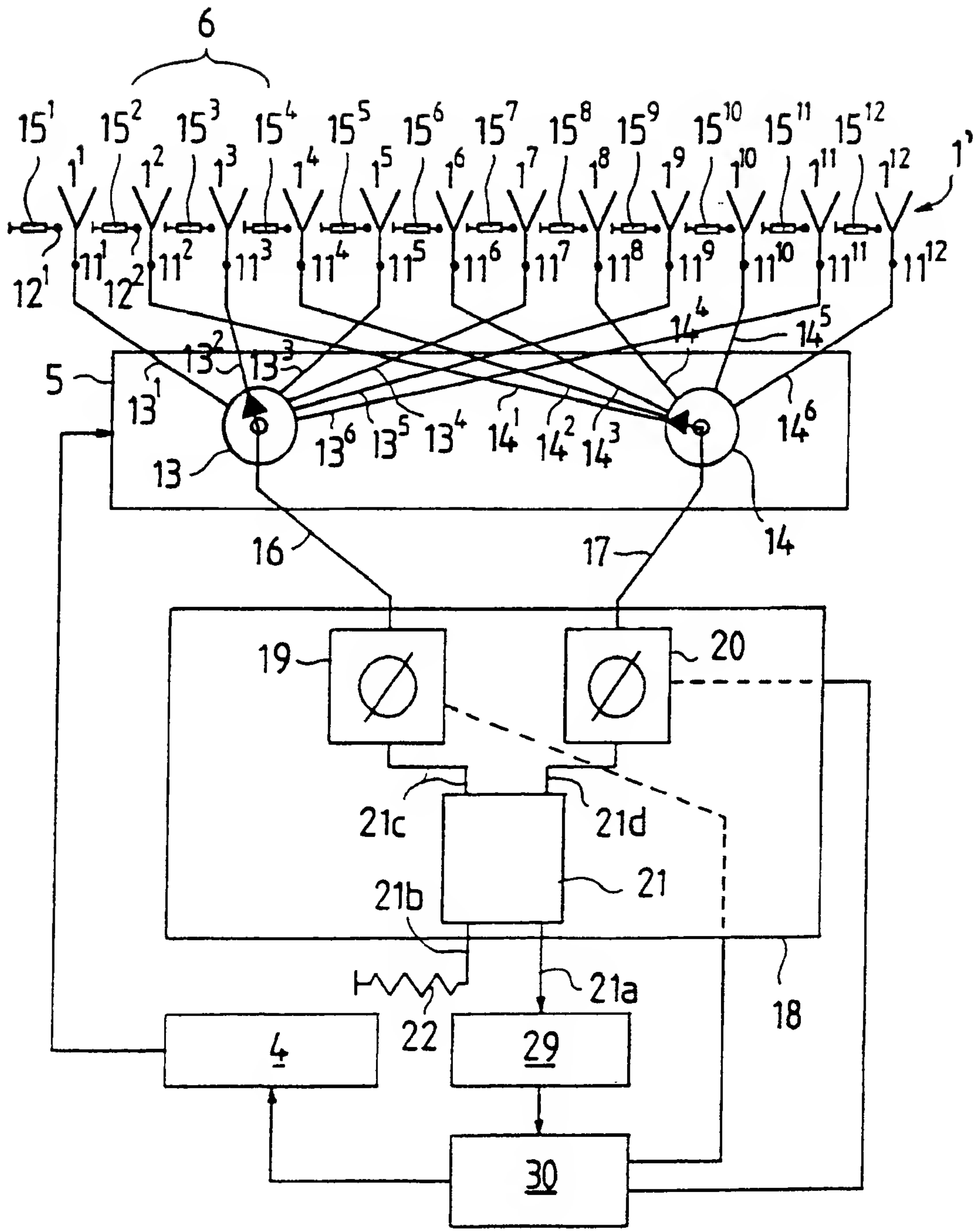

6
15^{1} 15^{2} 15^{3} 15^{4} 15^{5} 15^{6} 15^{7} 15^{8} 15^{9} 15^{10} 15^{11} 15^{12}
1^{1} 1^{2} 1^{3} 1^{4} 1^{5} 1^{6} 1^{7} 1^{8} 1^{9} 1^{10} 1^{11} 1^{12} 1'
12^{1} 11^{1} 12^{2} 11^{2} 11^{3} 11^{4} 11^{5} 11^{6} 11^{7} 11^{8} 11^{9} 11^{10} 11^{11} 11^{12}
14^{4} 14^{5}
5
13^{1} 13^{2} 13^{3} 13^{4} 13^{5} 13^{6}
14^{1} 14^{2} 14^{3} 14^{6}
13
14
16
17
19
20
21c
21d
21
21b
21a
22
18
4
29
30

Fig.4

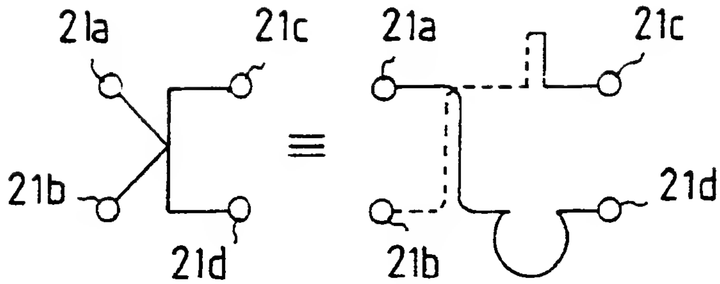


Fig.5

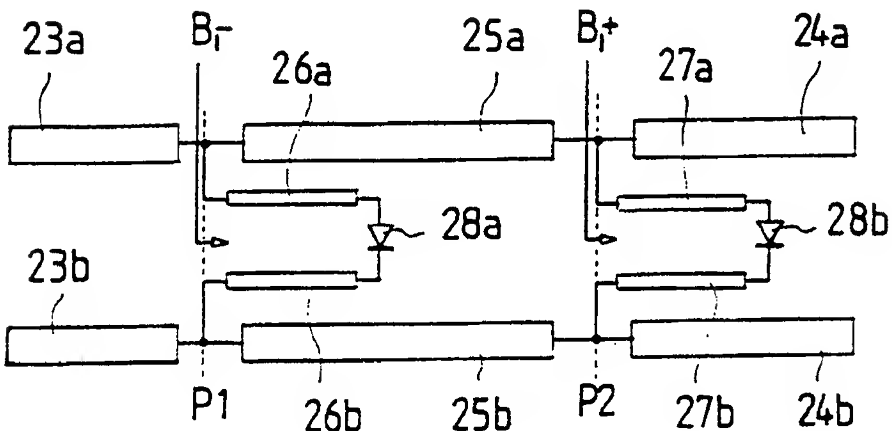


Fig.6

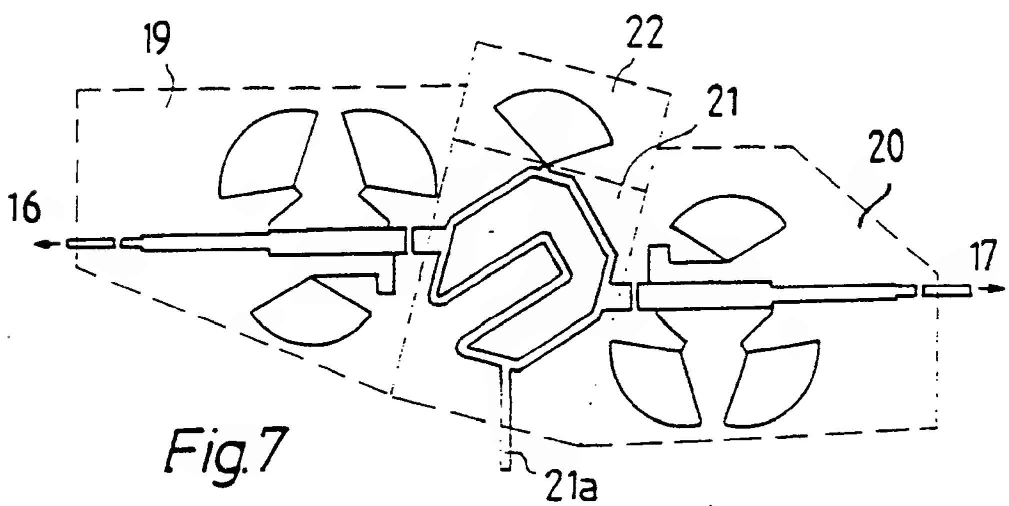
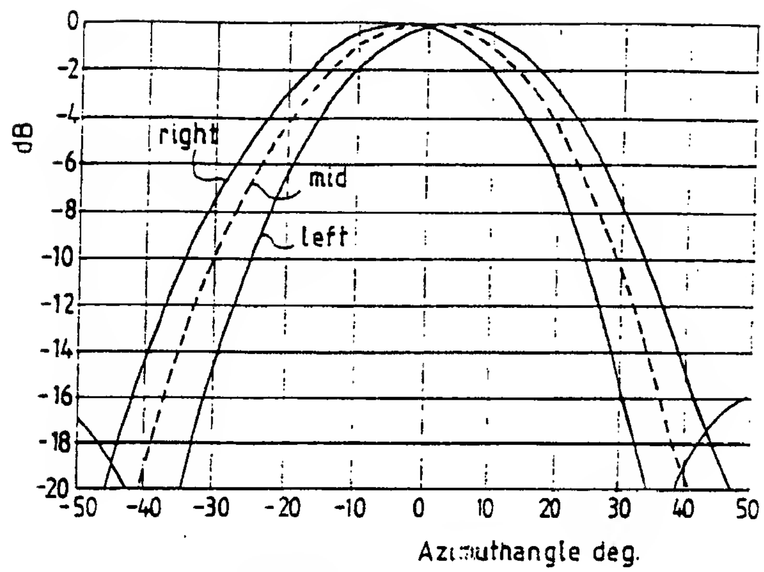
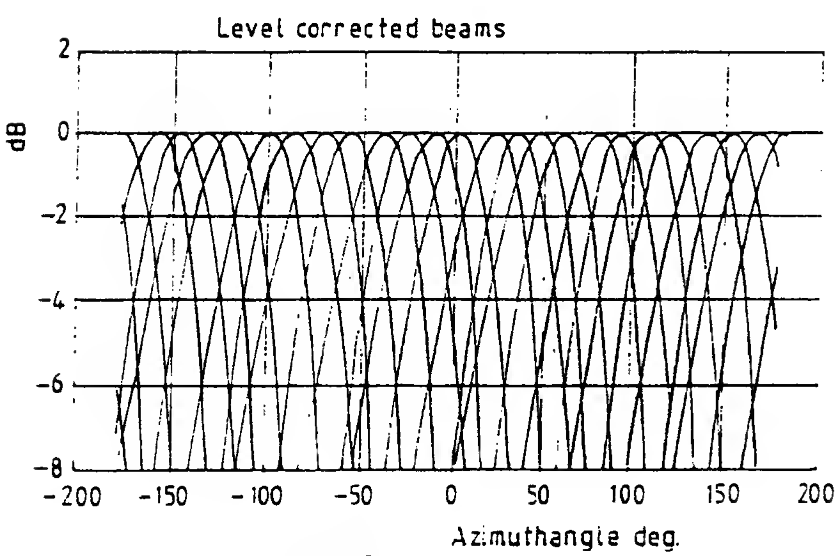


Fig.7



right
mid
left
dB
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-50
-40
-30
-20
-10
0
10
20
30
40
50
Azimuthangle deg.

Fig.8a



Level corrected beams
dB
2
0
-2
-4
-6
-8
-200
-150
-100
-50
0
50
100
150
200
Azimuthangle deg.

Fig.8b

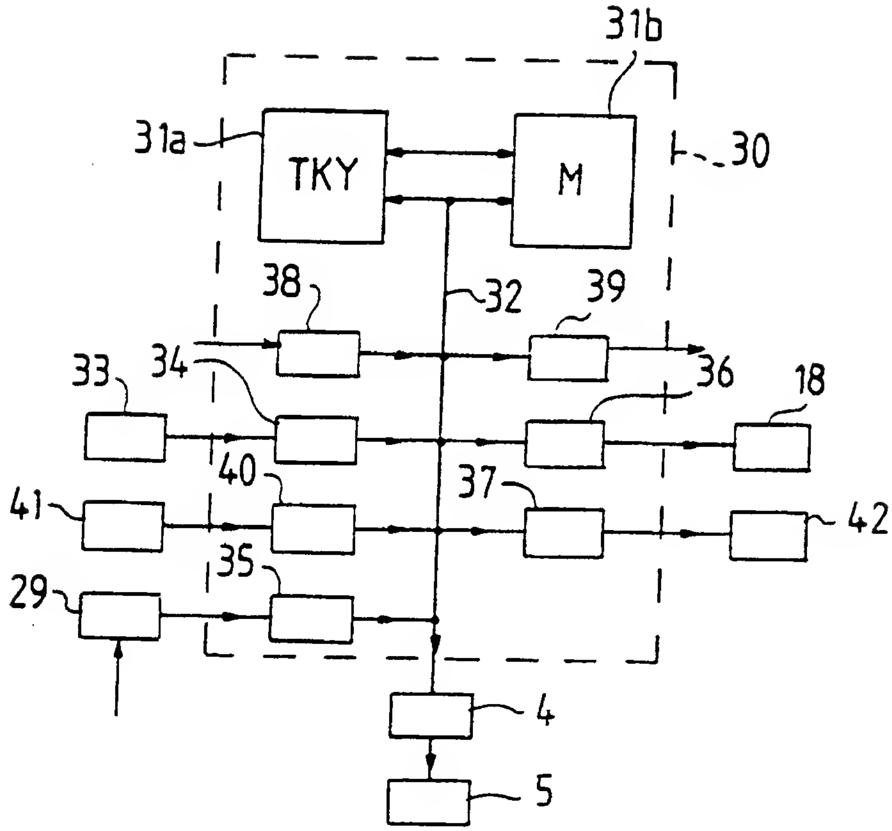


Fig.9

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Application Number

EP 92 20 3336
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	GLOBECOM`85 IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE vol. 3, December 1985, NEW ORLEANS,LOUISIANA pages 3851 - 3855 HADDAD ET AL. 'LAND VEHICLE ANTENNAS FOR SATELLITE MOBILE COMMUNICATIONS' * the whole document * ---	1,9,10	H01Q1/32 H01Q21/20 H01Q9/04 H01Q3/24
Y	ELECTRONICS & COMMUNICATIONS IN JAPAN, PART I - COMMUNICATIONS vol. 71, no. 4, 1988, NEW YORK US pages 117 - 124 HORI ET AL. 'Switched-Element Spherical Array Antenna for Wide Scan Angle' * page 123, paragraph 6 - page 124; figure 2 * ---	1,9,10	
A	37TH IEEE VEHICULAR TECHNOLOGY CONFERENCE June 1987, TAMPA,FLORIDA pages 104 - 112 TERADA ET AL. 'COMPACT MOBILE ANTENNAS FOR MOBILE SATELLITE COMMUNICATIONS' * page 107; figures 11-13 * ---	1-10	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01Q
A	DE-A-2 839 581 (LICENTIA) * page 3 - page 4; figure 1 * ---	1,5	
A	IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION vol. 37, no. 3, March 1989, NEW YORK US pages 281 - 288 DREWNIAK ET AL. 'ANSERLIN:A Broad-Band,Low-Profile,Circularly Polarized Antenna' * page 281 - page 282; figure 1 * ---	1-4	
	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 FEBRUARY 1993	ANGRABEIT F.F.K.

CATEGORY OF CITED DOCUMENTS

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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	1987 INTERNATIONAL SYMPOSIUM DIGEST ANTENNAS AND PROPAGATION vol. II, June 1987, BLACKSBURG,USA pages 894 - 897 HUANG ET AL. 'L-BAND SATELLITE COMMUNICATION ANTENNAS FOR U.S. COAST GUARD BOATS,LAND VEHICLES,AND AIRCRAFT' * the whole document * -----	1,8-10	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	11 FEBRUARY 1993	ANGRABEIT F.F.K.

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L : document cited for other reasons

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